

INSTALLATION GUIDE

RADWIN TV WHITE SPACE

Release 1.0



RADWIN

FOR REGULATORY USES ONLY

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Chapter 1: Introduction

1.1 Scope of This Document

This document shows how to install RADWIN TV White Space radios.

For a detailed description of how to configure RADWIN TV White Space radios, see the RADWIN TV White Space Configuration Guide.

1.2 RADWIN TV White Space Overview

RADWIN's TV White Space uses the UHF band (470-698MHz) to deliver coverage for unserved and underserved rural customers using a Non-Line-Of-Sight (NLoS) solution that can penetrate foliage and challenging terrains. With a sector capacity of up to 300Mbps and a subscriber unit capacity of up to 150 Mbps (depending on frequency availability, range and topography) in a point-to-multipoint link, rural customers can be connected to broadband services.

Table 1-1: RADWIN TV White Space Basic Parameters

| Model Name | Max T-put (Mbps) | Input Voltage & Current | Form Factor | Enclosure Type | Oper. Temp |
|--|------------------|-------------------------|--------------------|----------------|--------------|
| RADWIN TV White Space: Base Station | 300 | 41.2-57VDC, 1.6A | TV White Space HBS | IP67/Type 4 | -40C to +60C |
| RADWIN TV White Space: Subscriber Unit | 150 | 42.5-57VDC, 0.7A | TV White Space SU | IP67/Type 4 | -40C to +60C |

1.2.1 Radio Units

There are two types of outdoor radio units (ODUs): Base Stations, and Subscriber Units

- Base Station - With an external antenna.

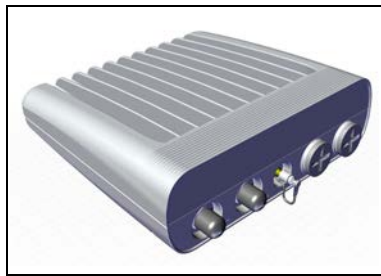


Figure 1-1: Base Station radio

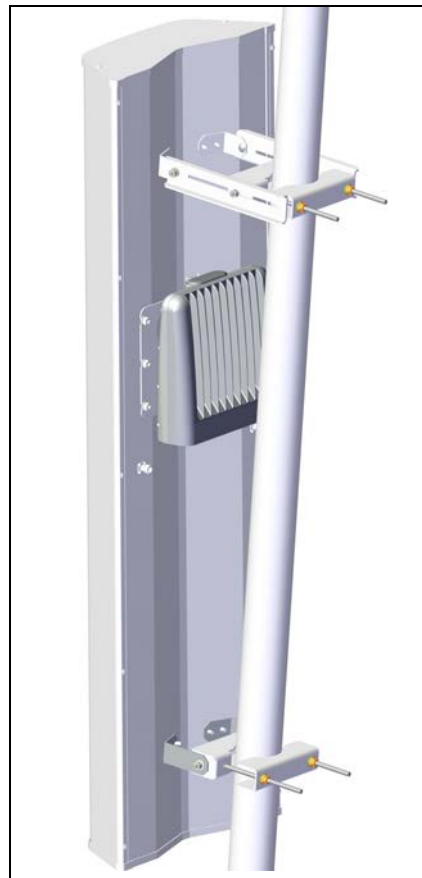


Figure 1-2: Base Station with external antenna

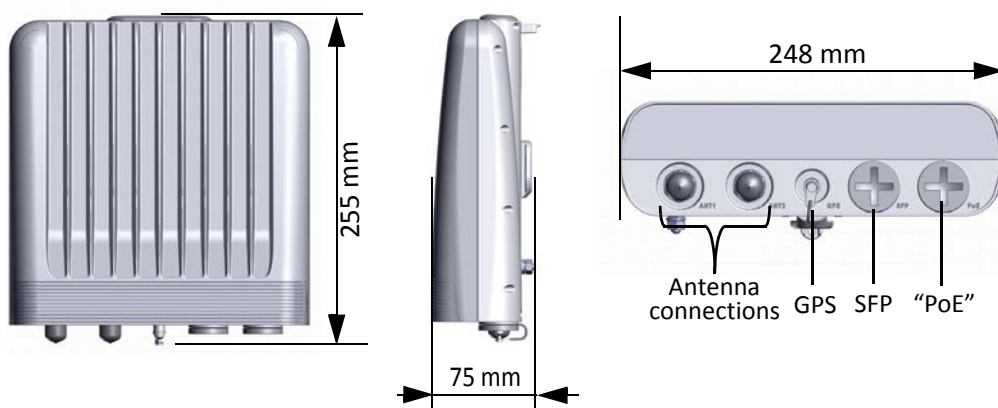


Figure 1-3: Base Station radio external dimensions

- Subscriber Unit - this unit has an integrated antenna.



Figure 1-4: Subscriber Unit

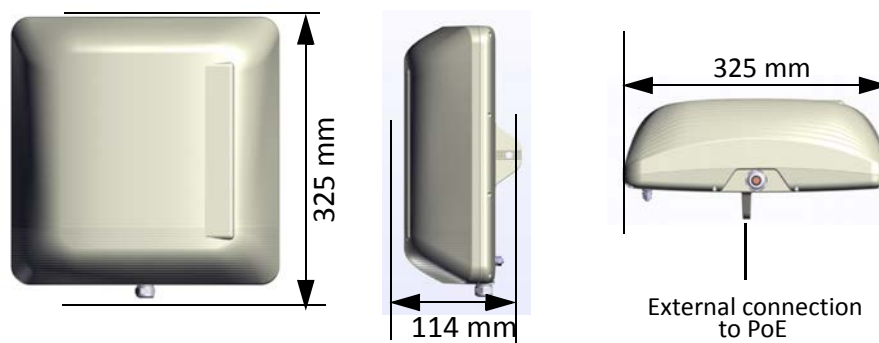


Figure 1-5: Subscriber Unit radio external dimensions

1.2.2 Method of Work

The radio units communicate with the service provider and users through PoE devices. The communication protocol for both the service provider and the users is Ethernet.

See [Figure 1-6, RADWIN TV White Space Connection Scheme](#):

- For each installation, permission must be granted from local regulatory authorities for the specific working frequencies for both the base station and the subscriber unit.
- A PoE device is connected to power and the communications network:
- Using CAT-5e cables, the radio units are connected to power and the communications network via a Power-over-Ethernet (PoE) device.
- The radio units and PoE devices are also connected to ground.
- The radios communicate with each other via the air interface.



Note

For simplicity, Lightning Protection Units (LPU) are not shown in [Figure 1-6](#), but these are recommended. See [Mounting the Lightning Protection Units on page 2-14](#) for directions on how to install the LPUs.

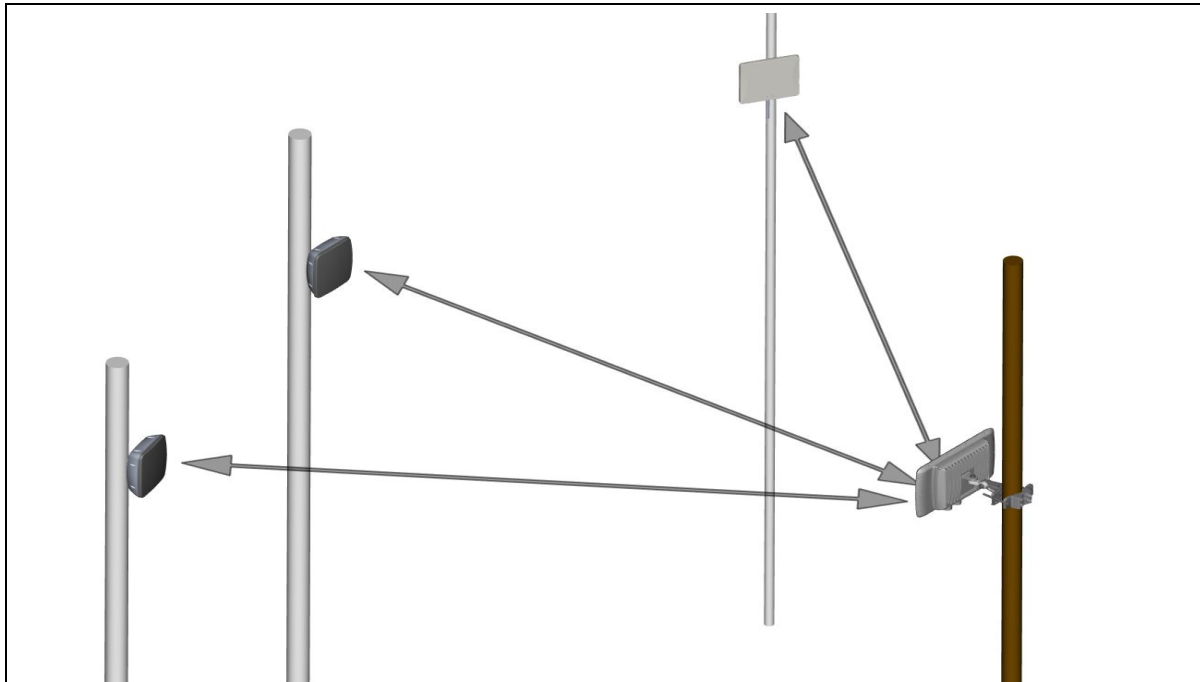


Figure 1-6: RADWIN TV White Space *Connection Scheme*

1.2.3 Management Tools

RADWIN Web Interface

The Web Interface enables you to carry out unit and/or sector management functions using a Web browser.

It may be used to -

- Set or change radio unit parameters in the field
- Establish a sector
- Check link parameters and make changes
- View the link Inventory
- Inspect the Events logs

1.3 Key features of TV White Space

- » Ethernet connectivity
- » Dual carrier base station with up to 4 channels per carrier¹
- » Embedded GPS
- » Advanced OFDM & MIMO 2x2 for non-line of site (NLoS) performance
- » Inter & intra site sync to reduce self interference

¹ FCC regulations. Max of 3 channels per carrier for ETSI regulations

- » Regulations supported - FCC/ETSI (the product shipped to any given regulatory environment can only support those regulations)
- » Simple to deploy
- » Web Interface for sector management
- » Fully integrated with RADWIN's family of solutions
- » Separate uplink and downlink configurable Maximum Information Rate (MIR)
- » IP-67 compliant

1.4 What's New in Release 1.0

- » See the Release Notes for details

1.5 Notifications

Notifications consist of Notes, Cautions, and Warnings:



Caution: Risk of damage to equipment or of service degradation



Warning: Risk of danger to persons operating near the equipment



The purpose of a Note is to:

- Draw your attention to something that may not be obvious
 - Emphasize a special feature
 - Provide additional background
-

Chapter 2: Installation Steps

To install and establish a basic connection with a radio unit, carry out the steps shown below. Print out this list, and place a checkmark next to a completed task.

Table 2-1: Installation Check-List

| Step | Action | Page | Done? |
|------|---|-----------|-------|
| | Before deploying at installation site | | |
| 1. | <i>Prepare Laptop</i> | page 2-2 | |
| 2. | <i>Connect Laptop to Radio Unit</i> | page 2-2 | |
| 3. | <i>Update Connectivity Parameters of Radio Unit</i> | page 2-4 | |
| 4. | <i>Check items to be installed</i> | page 2-5 | |
| 5. | <i>Prepare Tools</i> | page 2-6 | |
| | Installation | | |
| 6. | <i>Mount the HBS</i> | page 2-6 | |
| 7. | <i>Connect HBS antenna</i> | page 2-7 | |
| 8. | <i>Install SU Mounting Kit</i> | page 2-9 | |
| 9. | <i>Mounting the SU</i> | page 2-13 | |
| 10. | <i>Ground Radio Unit</i> | page 2-13 | |
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| 12. | <i>Waterproofing</i> | page 2-17 | |
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| 13. | <i>Connect Radio (External Connections)</i> | page 2-18 | |
| 14. | <i>Check Connectivity to Radio</i> | page 2-19 | |
| 15. | <i>Request (and receive) permitted frequencies</i> | page 2-20 | |
| 16. | <i>Activate HBS</i> | page 2-20 | |
| 17. | <i>Align SU Unit</i> | page 2-21 | |

2.1 Prepare Laptop

Configure IP address and subnet mask of laptop as follows:

- Control Panel -> Network and Internet -> Network and Sharing Center -> Change Adapter settings -> click on Network Interface Card name
- Properties -> Select Internet Protocol Version 4 (TCP/IPv4) -> Properties -> set IP address to 10.0.0.100 and Subnet mask to 255.255.0

2.2 Connect Laptop to Radio Unit

Connect PoE to power, connect the laptop's ethernet port to the IN (or LAN) port on the PoE, then connect the OUT (or PoE) socket on the PoE to the appropriate port on the radio unit. Make sure you are using the appropriate PoE for your specific radio unit.

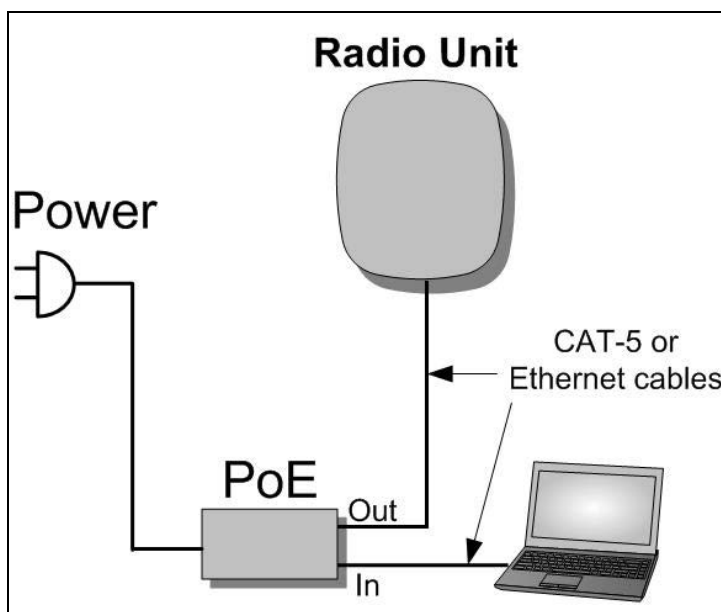


Figure 2-1: Connecting laptop to a radio unit

2.2.1 TV White Space HBS Units

Connect to port labeled -> "PoE"



Figure 2-2: PoE port: HBS radio unit

2.2.2 TV White Space SU Units

Connect to input port



Figure 2-3: Input port: SU radio unit

2.3 Update Connectivity Parameters of Radio Unit

2.3.1 HBS Units



1. If you have not already done so, connect the radio to your PC/network and voltage via its input port.
2. Enter its IP address in a web browser (default value: 10.0.0.120).
3. From the login page, enter username **admin** and password **netwireless**.

4. Click the **Configure** icon



5. From the window that appears, select **Management -> Network**
6. Enter the new IP address, Subnet Mask and Default Gateway in accordance with your radio plan, then click **Save**.
7. You will be warned that the device (HBS radio unit) will be reset. If all the values are correct, click **OK**.
8. From a command line, ping radio unit using new IP address to verify change.

Once you are finished with the steps above, disconnect the radio unit and prepare it for deployment in the field.

2.3.2 SU Units



1. If you have not already done so, connect the radio to your PC/network and voltage via its input port.
2. Enter its IP address in a web browser (default value: 10.0.0.120).
3. From the login page, enter username **admin** and password **netwireless**.

4. Click the Configure icon



5. Select **Air Interface -> Radio**
6. Enter the Sector ID, and if applicable, Channel Bandwidth, then click Save.
7. Select **Management -> Network**
8. Enter the new IP Address, Subnet Mask, and Default Gateway, then click **Save**.
9. You will be warned that the device will be reset. If all the values are correct, click **OK**.
10. From a command line, ping radio unit using new IP address to verify change.

Once you are finished with the steps above, disconnect the radio unit and prepare it for deployment in the field.

2.4 Check items to be installed

- Radio unit + mounting kit
- 2 LPUs for each radio (recommended)
- PoE (if outdoor, requires mounting kit)
- CAT-5e cables
- Grounding cables (10 AWG) for radio unit, LPUs and outdoor PoE (if used)
- External antenna + HBS mounting kit (if installing an HBS)
- Standard mounting kit (if installing an SU)
- RF cables

2.5 Prepare Tools

- Crimping tool
- Spanner/wrench 13mm (1/2")
- Cable ties
- Sealing material
- Waterproofing tape (like Scotch 23)

2.6 Mount the HBS

The HBS can be mounted together with its antenna, or separately on its own mount.

2.6.1 Mounting the HBS with its antenna

Mount the HBS on the antenna using the mounting plate:

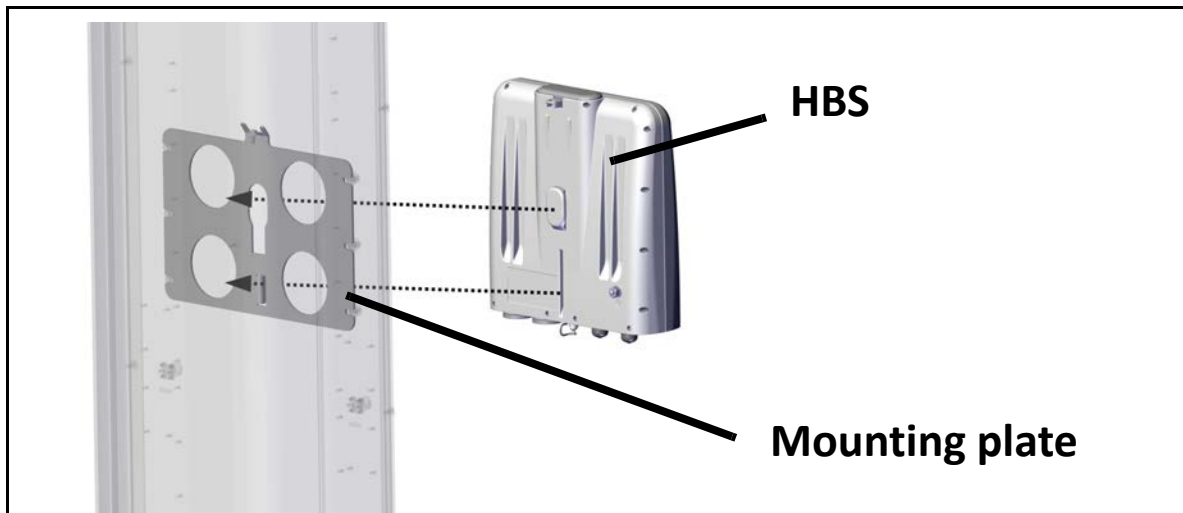


Figure 2-4: Mount the HBS on its mounting plate

Push down the HBS until you hear a click, then fasten the locking screw as shown:

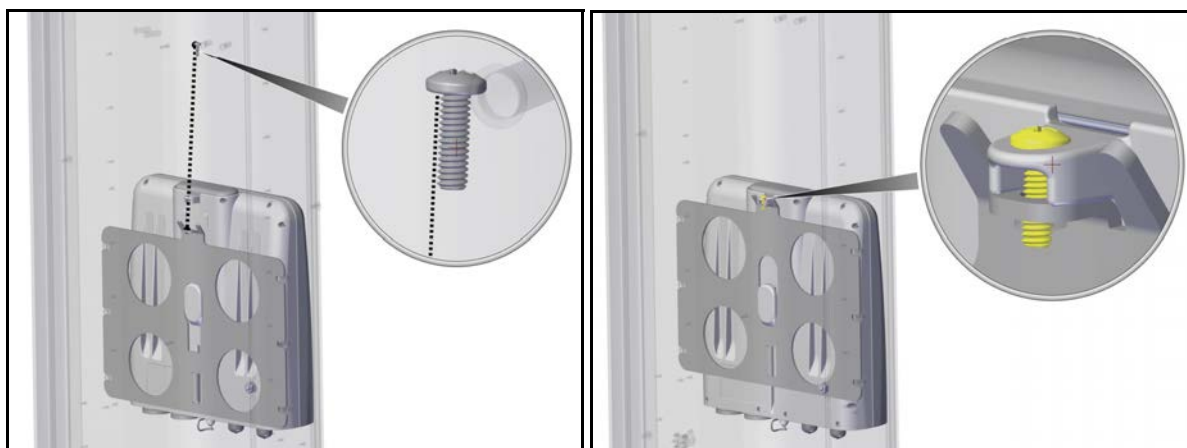


Figure 2-5: Fasten the locking screw

Mount the antenna on a pole using its mounting assembly:

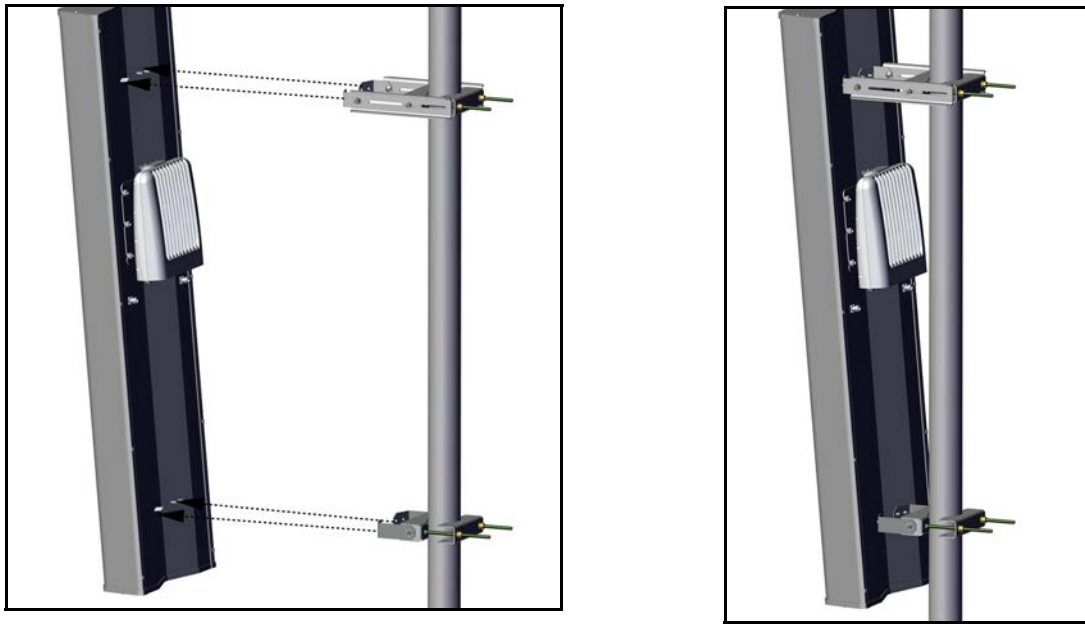


Figure 2-6: Mount HBS/ antenna on pole

2.6.2 Mounting the HBS adjacent to its antenna

2.7 Connect HBS antenna

Connect CAT-5e cables between the HBS and antenna as shown:



Figure 2-7: Connect antenna cables - HBS mounted on antenna

Figure 2-8: Connect antenna cables - HBS mounted adjacent to its antenna

2.8 Install SU Mounting Kit

2.8.1 Standard Mounting Kit

Use the standard mounting kit for SU radio units

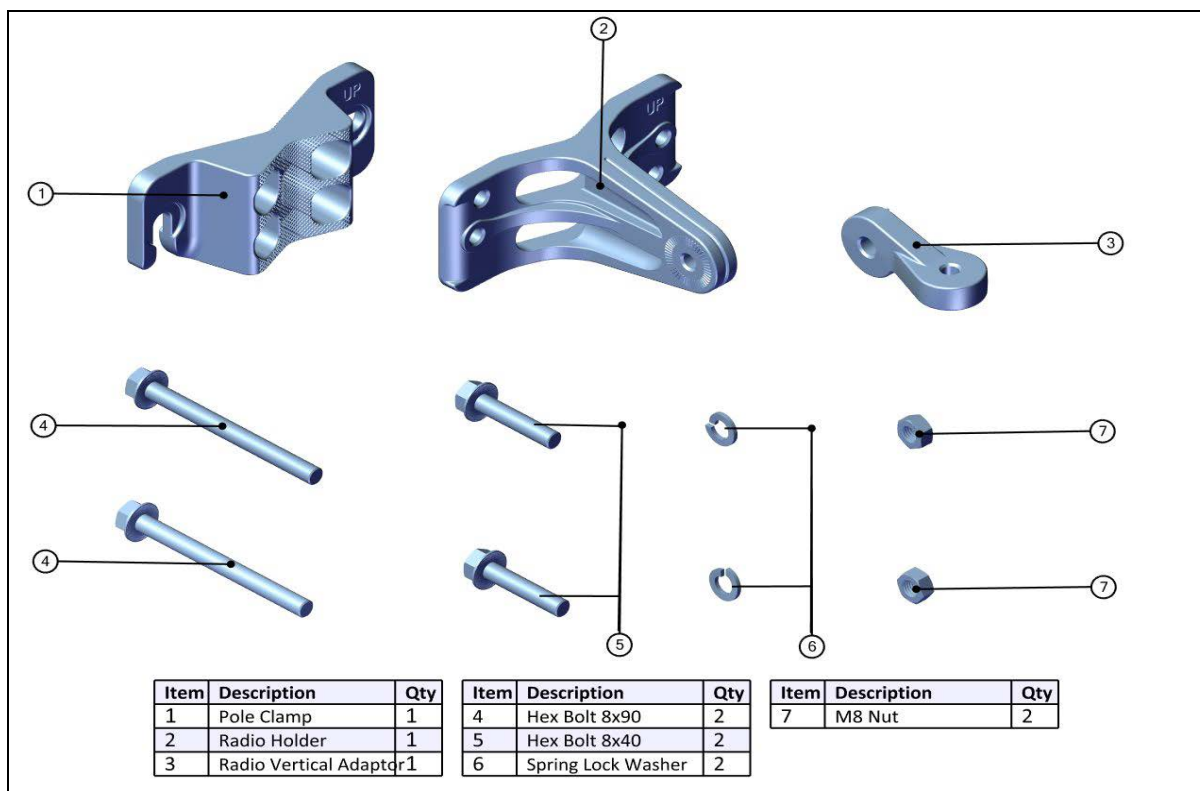


Figure 2-9: Standard Mounting Kit Contents



Tighten all bolts with a torque of 15Nm.

The mounting kit can be used on a vertical or horizontal pole or on a wall:

| | |
|---------------------------------|---------------------------|
| Vertical Pole | page 2-10 |
| Horizontal Pole | page 2-12 |
| Wall | page 2-12 |

2.8.2 Vertical Pole

The mounting kit can be used on a thin, medium, or thick pole.

| | | |
|--------------------|-----------------|---------------------------|
| <i>Thin Pole</i> | Dia. 3/4 -1 1/2 | page 2-10 |
| <i>Medium Pole</i> | Dia. 2 - 3 | page 2-11 |
| <i>Thick Pole</i> | Dia. > 3 | page 2-11 |

Thin Pole

1. Diameter 3/4 to 1 1/2: Position the pole clamp as shown in the following figures. Do not tighten the bolts all the way.

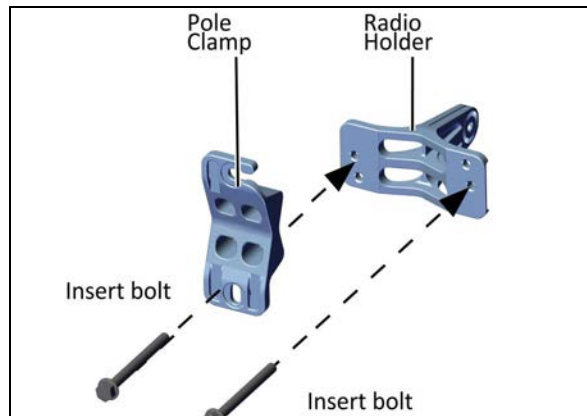


Figure 2-10: Connect Pole Clamp to Radio Holder

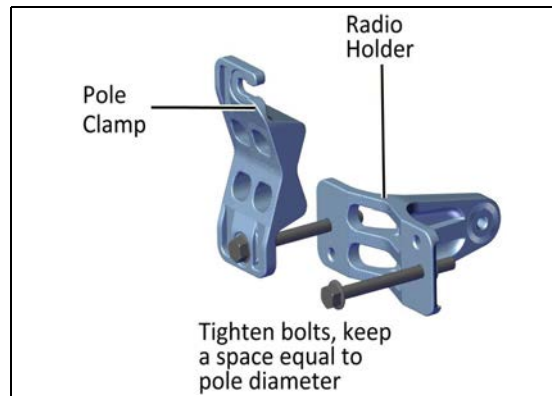


Figure 2-11: Partially tighten bolts

2. Place this “unit” on the pole where you want to mount the device. Once it is in place, rotate the pole clamp as shown, then tighten both bolts.

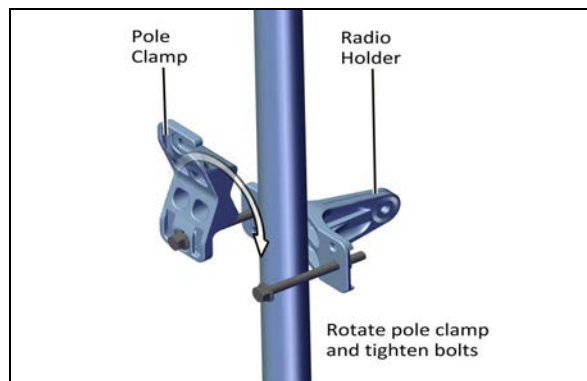


Figure 2-12: Rotate Clamp and tighten bolts

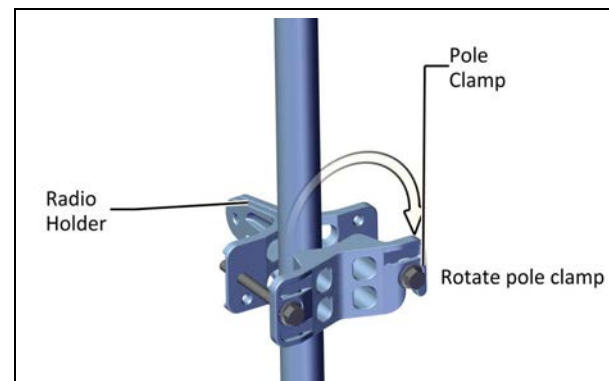


Figure 2-13: Completely tighten bolts

Medium Pole

1. Diameter 2 to 3: Position the pole clamp as shown in the following figures. Do not tighten the bolts all the way.

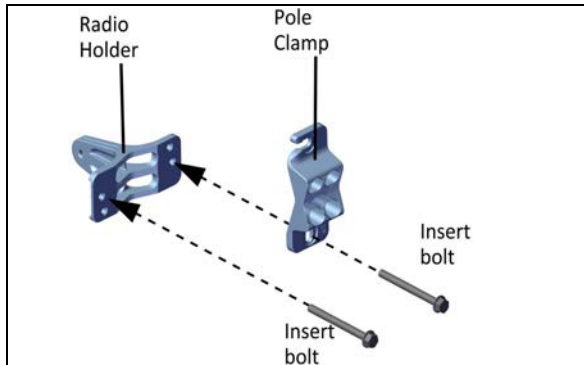


Figure 2-14: Connect Pole Clamp to Radio Holder

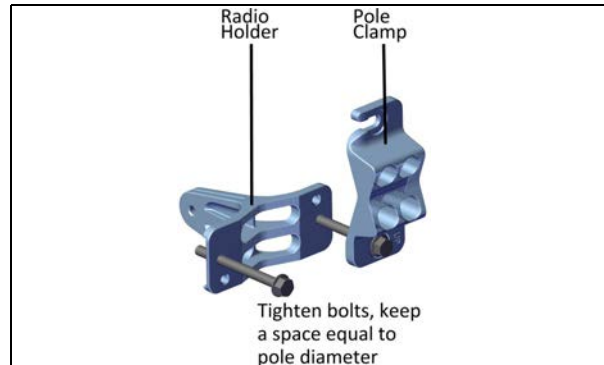


Figure 2-15: Tighten bolts

2. Place this “unit” on the pole where you want to mount the device. Once it is in place, rotate the pole clamp as shown, then tighten both bolts.

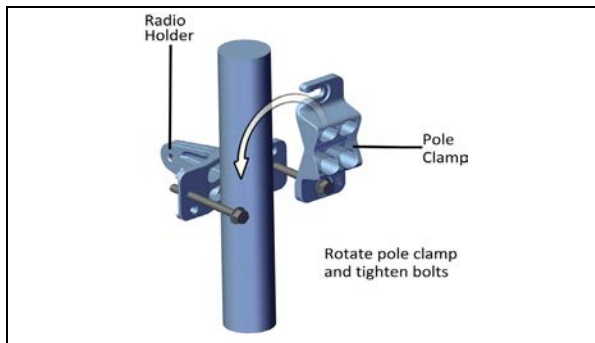


Figure 2-16: Rotate Clamp

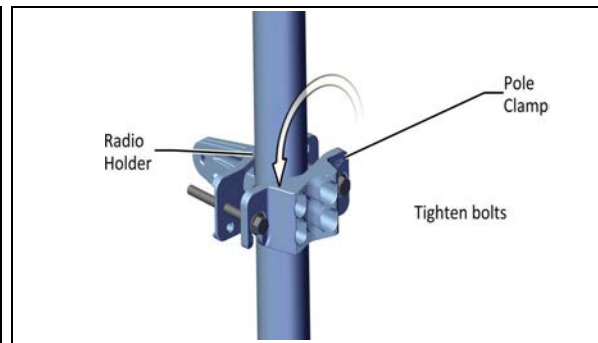


Figure 2-17: Completely tighten bolts

Thick Pole

1. Diameter larger than 3: Use worm drive clamps (not supplied), threaded through the holes as shown:



Figure 2-18: Mounting kit on a thick pole

The pole clamp is not needed.

2.8.3 Horizontal Pole

Installing the mounting kit on a horizontal pole is done in a similar manner to that on a vertical pole (thin, medium, or thick sizes):

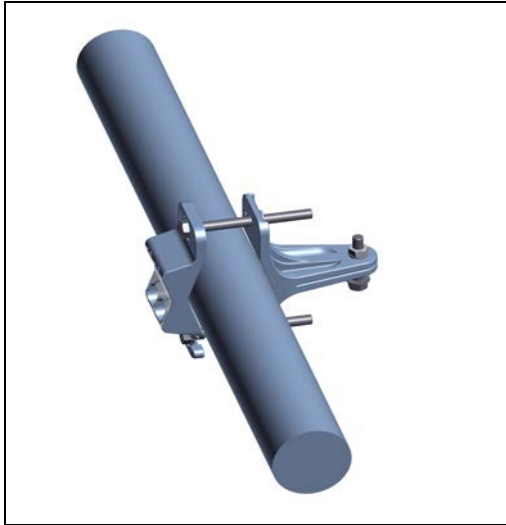


Figure 2-19: Mounting Kit on a horizontal pole

2.8.4 Wall

Use two mounting screws (not included) appropriate for the type of wall to install the mounting kit on a wall. Make sure you use the indicated holes.

The pole clamp is not needed.

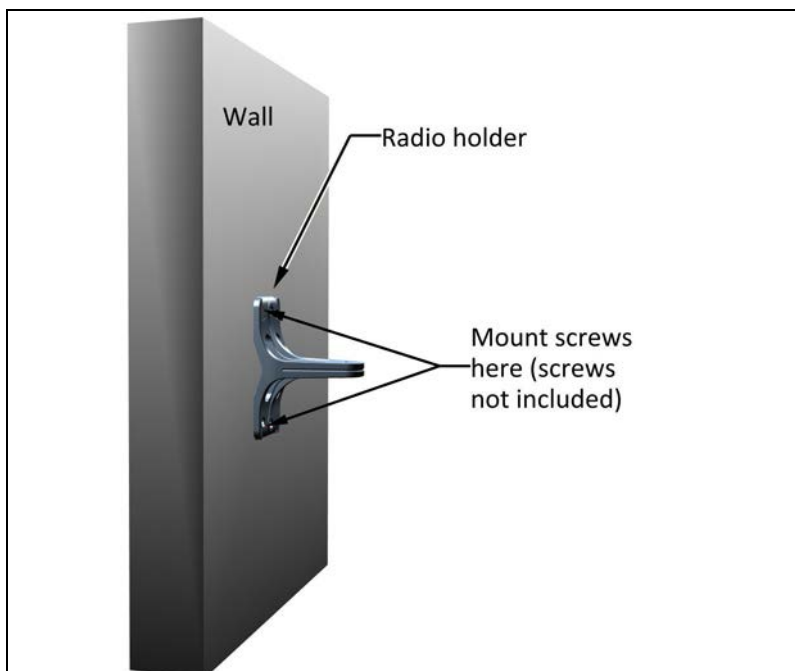


Figure 2-20: Mounting kit on a wall

2.9 Mounting the SU

SU radios use the standard mounting kit as shown in [Figure 2-21](#):



Figure 2-21: Mounted SU radio unit

2.10 Ground Radio Unit

Connect a ground cable to the indicated ground connection on the radio unit as shown in the sections below:

2.10.1 HBS Units



Figure 2-22: Ground: HBS radio unit

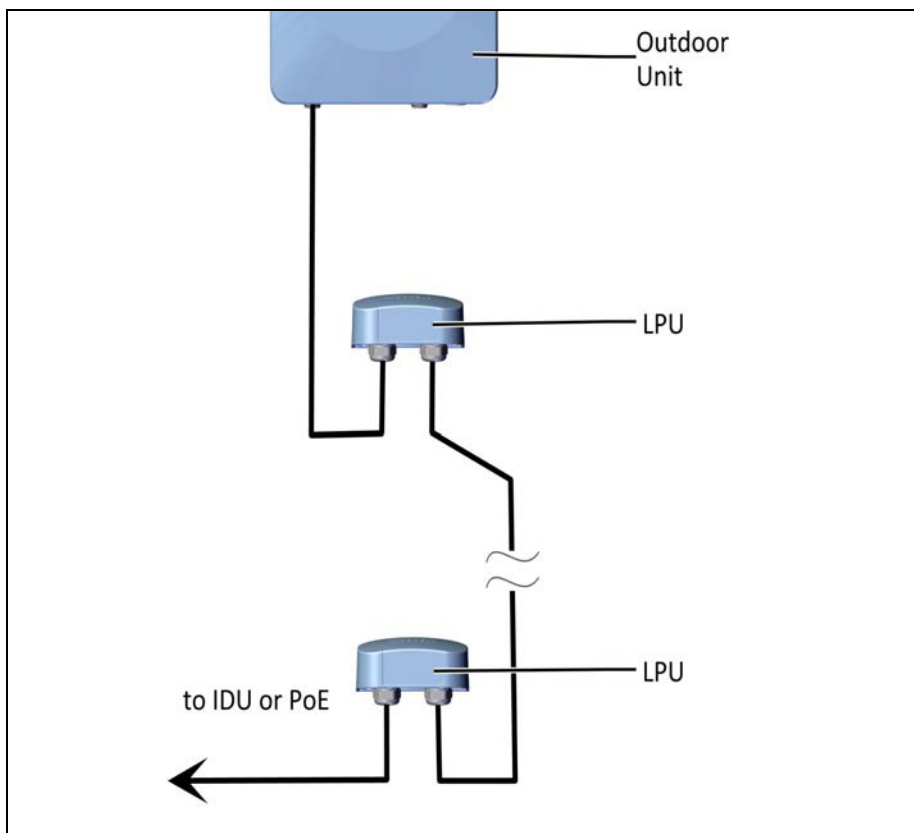
2.10.2 SU Units



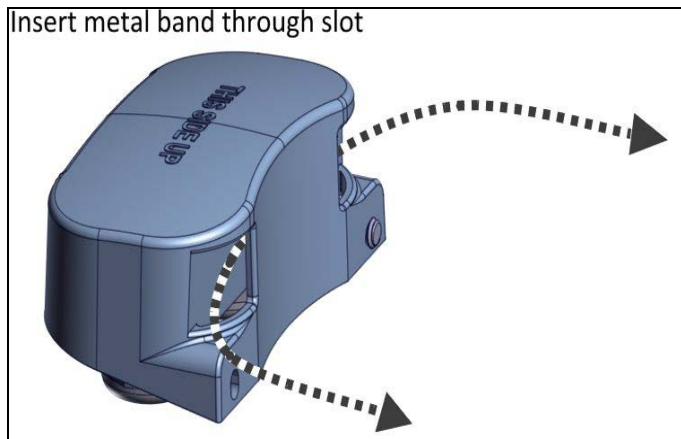
Figure 2-23: Ground: SU radio unit

2.11 Mounting the Lightning Protection Units

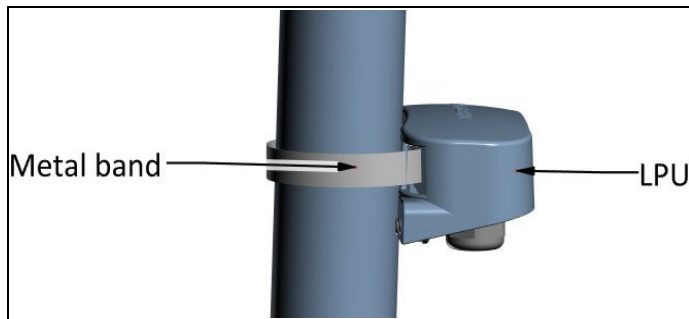
- We recommend using two lightning protection units (LPUs) for each radio unit installation: One near the radio unit and one near the PoE.
- The LPU can be mounted on a pole.
- Make sure the LPU is oriented with the cable glands oriented towards the bottom.
- Mount one LPU near the radio unit, and the second near the PoE:



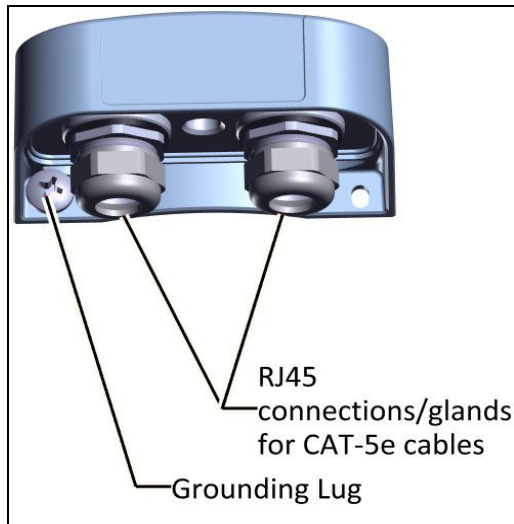
1. Insert the metal band through the slots on the LPU as shown:



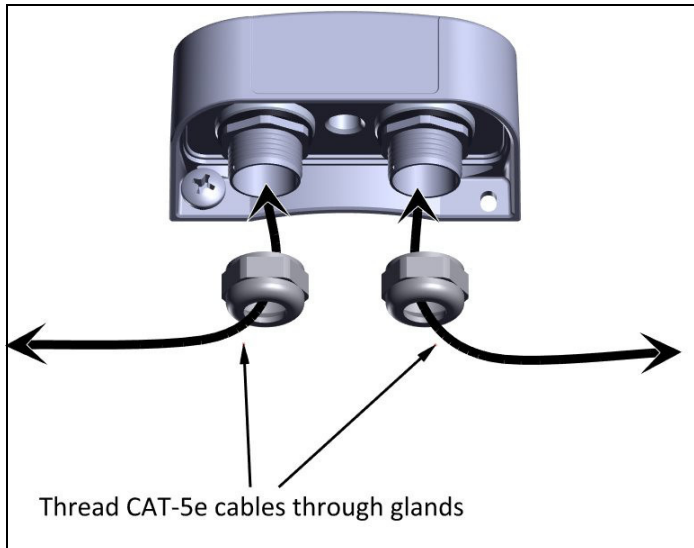
2. Tighten the metal band.



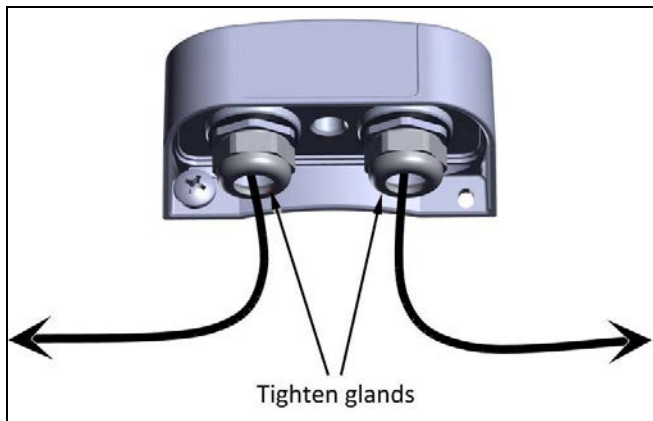
3. Connect the grounding lug to a ground source.



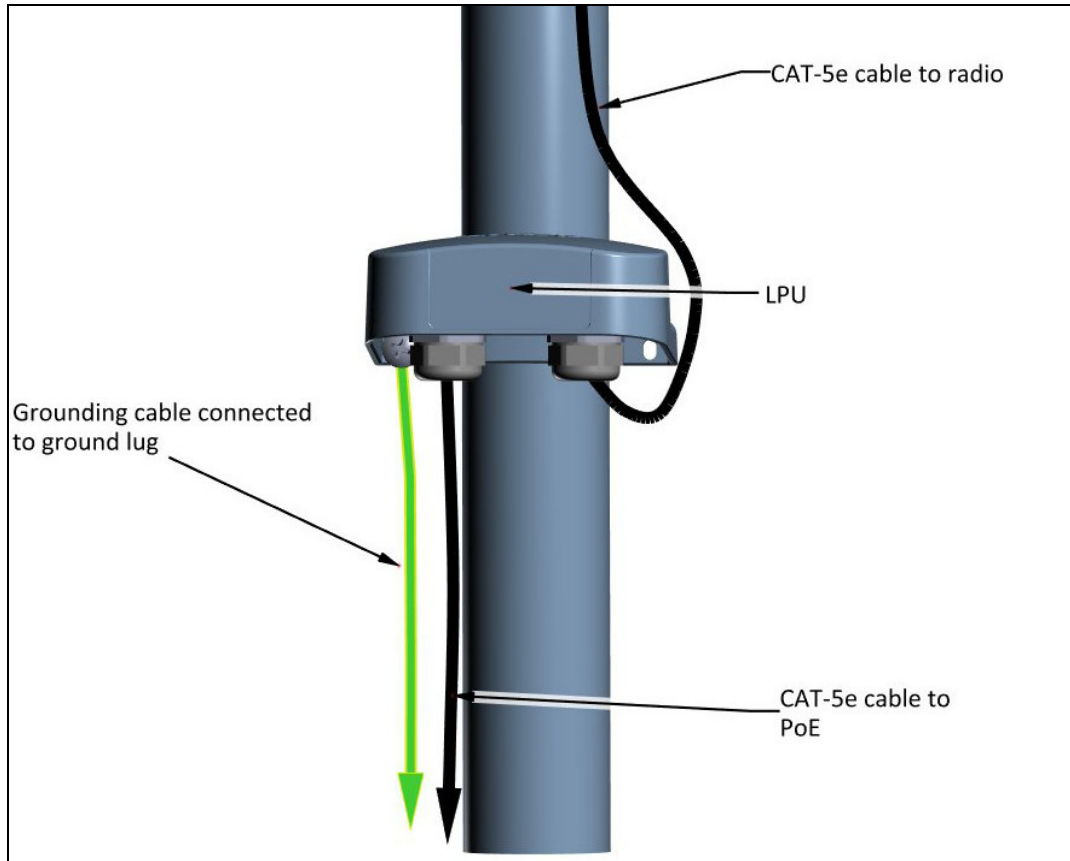
4. Remove the cable glands, and thread the CAT-5e cables through them:



5. Connect the cables to the LPU's sockets, and the glands around the cables as shown:



6. Route one CAT-5e cable up to the radio unit, and the other down to the PoE (via the lower LPU). An LPU installed on a pole is shown below:



2.12 Waterproofing

Protect all outdoor connections from rain, dust, moisture and salt by taping the cable/gland connection with an appropriate sealant tape. We recommend using Scotch™ 23 splicing tape or similar.

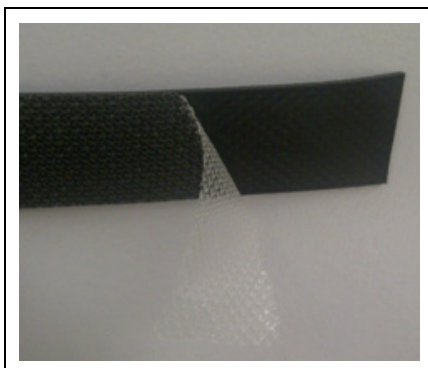


Figure 2-24: Sealant tape

Add tape as shown below.



Figure 2-25: Applying sealant tape to an external connection

2.13 Connect Radio (External Connections)

2.13.1 HBS Units

1. Connect a CAT-5e cable to the input port of the radio as shown:



Figure 2-26: Input port: HBS unit (connection label: "PoE")

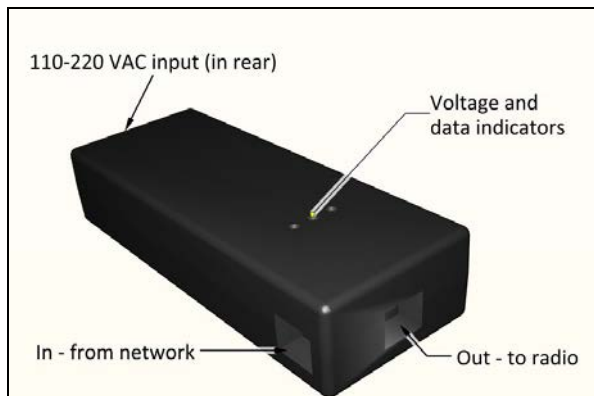
2.13.2 SU Units



Figure 2-27: Input port: SU unit

2. Add sealant tape to the connections (see ["Waterproofing" on page 2-17.](#))
3. Route the CAT-5e and ground cables down from the radio to a PoE via 2 LPUs: one near the radio, one near the PoE. Fasten CAT-5e cable connections with a cable gland, add sealant tape.
4. Connect ground cable to ground.
5. Perform final connections via a PoE, depending on the type of PoE you are using, as follows:

Indoor PoE



- a. Connect CAT-5e cable from lower LPU to "Out" port
- b. Connect LAN cable to "In" port.
- c. Connect power cable

2.14 Check Connectivity to Radio

1. Connect to radio unit:
 - From a laptop in the field: Disconnect the PoE from the communications network (LAN connection), and connect the laptop.

- From the NOC: Keep the PoE connected to the LAN.
2. From a command line, ping radio using radio's IP address.

2.15 Request (and receive) permitted frequencies

- Make sure the HBS is connected to the internet

Repeat the following for each radio unit (both the HBS and each SU):

1. Note your precise latitude and longitude and the height from the ground of the unit. The permitted frequencies can differ from location to location and according to height.
2. Send your frequency request to the local authorities.
3. Receive the permitted frequencies from the local authorities.
4. Configure the radio unit to transmit/receive only in these frequencies.

The HBS can transmit only after it receives permitted frequencies from the local authorities. Until that happens, it is impossible for it to transmit.

The SU's permitted frequencies are a subset of the HBS's frequencies, and must be requested in addition to, and only after the HBS receives its permitted frequencies.



Caution

The SU can transmit only in response to a signal from the HBS. Although you can perform alignment before receiving its permitted frequencies, traffic can only be connected once the SU receives its valid frequencies.

In some cases, a token may be required to connect with the frequencies database of the local authorities.

2.16 Activate HBS

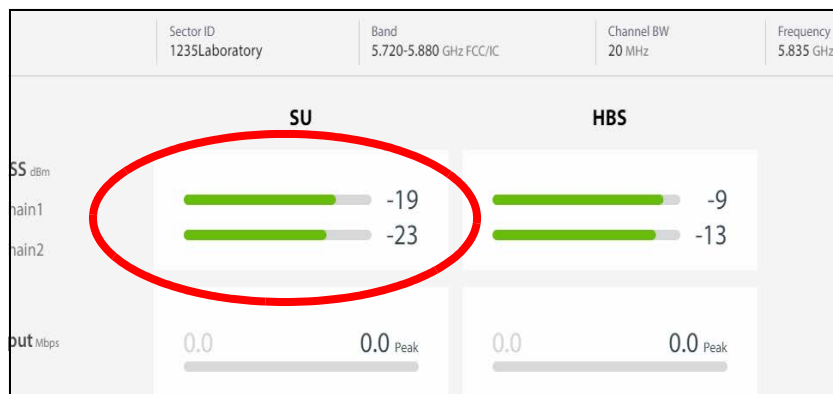
- You can only activate the HBS once it has received its permitted frequencies
1. Connect to radio unit:
 - From a laptop in the field: Disconnect the PoE from the communications network (LAN connection), and connect the laptop.
 - From the NOC: Keep the PoE connected to the LAN.
 2. In a web browser, enter the IP address of the HBS radio that is to be activated.
 3. From the login page, enter username **admin** and password **netwireless**.
 4. Select the Hub site by placing a checkmark next to its name:



5. You will see the blue Activate button enabled. Click it to start the Activation process.
6. Enter the parameters as requested in the windows that appear, and click **Next** when you are ready to move to the next one.
7. When you are finished, click the **Activate** button.
8. The main window will display a brief message saying the action was completed successfully, and after a few moments, the unit will be activated.

2.17 Align SU Unit

1. Make sure the HBS unit is activated (check with the NOC).
2. Point the SU in the general direction of the HBS unit.
3. Access the web interface (enter the unit's IP address in a web browser)
4. Log in using username **admin** and password **netwireless**.
5. From the main window, you can see the RSS (radio signal strength) as a green bar. While referring to this, do the following:
6. Swivel the unit 90° to the right slowly, 180° to the left, and then 90° back towards the base station. Note at which point the RSS value is maximum. Lock the unit at this point.
7. Preserving the horizontal orientation, repeat the above in elevation.
8. Once alignment is complete, tighten the bolt.



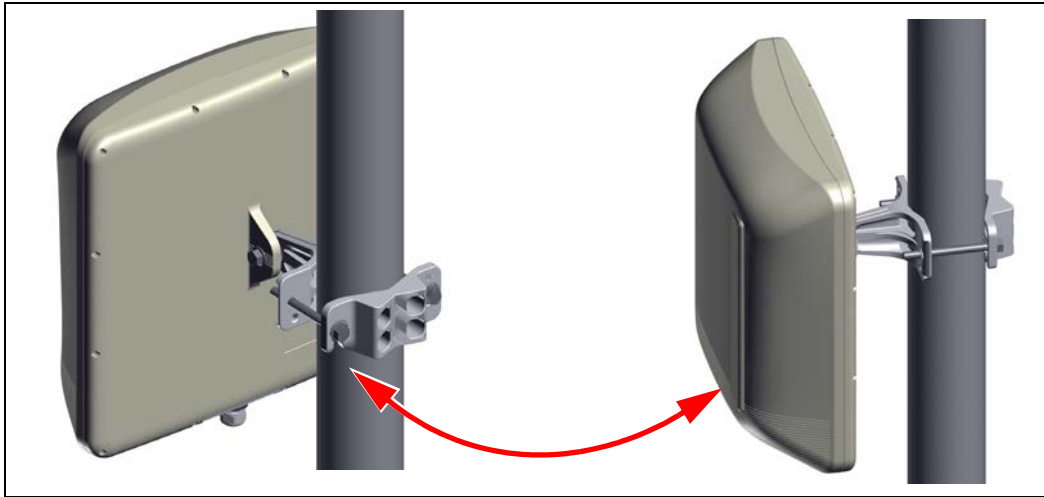


Figure 2-28: Swivel horizontally

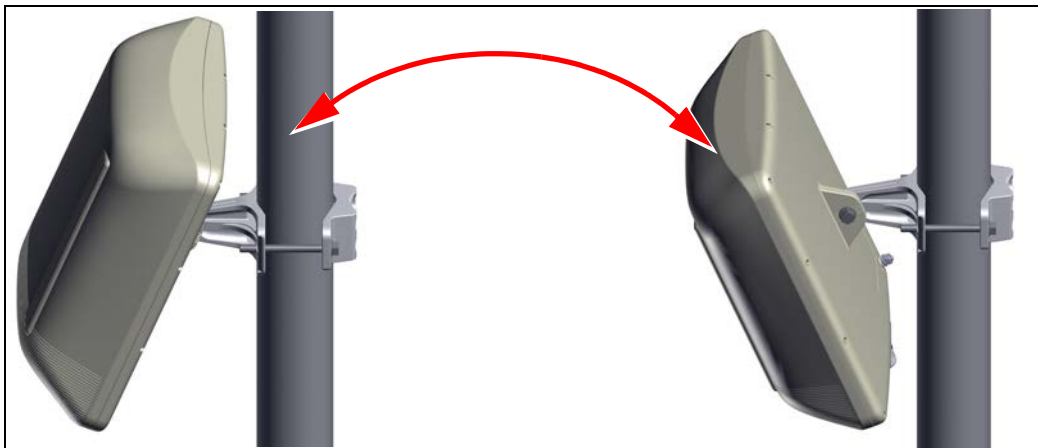


Figure 2-29: Swivel vertically



Figure 2-30: Tighten bolt



If you have not done so already, request permitted frequencies for the SU. This is done via the HBS. The HBS will not transmit to an SU any traffic on a frequency that has not been approved for that specific SU.

Chapter 3: Safety Practices and Provisions

3.1 Scope of this Chapter

This chapter describes various safety practices.

3.1.1 Preventing Overexposure to RF Energy

To protect against overexposure to RF energy, install the radio units so as to provide and maintain minimal separation distances from all persons.

When the system is operational, avoid standing directly in front of the antenna. Strong RF fields are present when the transmitter is on. The radio unit must not be deployed in a location where it is possible for people to stand or walk inadvertently in front of the antenna.

3.1.2 Grounding

All RADWIN products should be grounded during operation. In addition:

- All ODUs should be grounded by a wire with diameter of at least 10 AWG.
- Rack-mounted equipment should be mounted only in grounded racks and cabinets.

Further, you should -

- Always make the ground connection first and disconnect it last
- Never connect telecommunication cables to ungrounded equipment
- Ensure that all other cables are disconnected before disconnecting the ground

3.1.3 Protection against Lightning

The use of lightning protection is dependent on regulatory and end user requirements. All RADWIN outdoor units are designed with surge limiting circuits to minimize the risk of damage due to lightning strikes. RADWIN recommends the use of additional surge arrestor devices to protect the equipment from nearby lightning strikes.

3.1.4 General

- Installation of outdoor units must be contracted to a professional installer
- Before working on equipment connected to power lines or telecommunication lines, remove jewelry or any other metallic object that may come into contact with energized parts
- Use extreme care when installing antennas near power lines
- Use extreme care when working at heights
- When using an AC power source for RADWIN devices, always use the AC power adapter supplied by RADWIN
- Use the right tools!
- Do not mount a radio unit upside down or horizontally. Doing this may void your product warranty.

3.1.5 Internal ESD Protection circuits

RADWIN equipment is designed to meet the ETSI/FCC/Aus/NZ/CSA EMC and Safety requirements. To fulfill these requirements, the system's Telecom lines at the radio unit/PoE are Transformer-isolated and include internal ESD (Electro-Static-Discharge) Protection circuits.



When installing an AC powered SU: To maintain Overvoltage (Installation) Category II, install a suitable surge suppressor device in the branch circuit to limit expected transients to Overvoltage Category II values.

The limits are based on IEC60664 and are also located in Table 2H of UL60950 (for mains $\leq 150V$, the transient rating is 1500V; for $150V < \text{mains} \leq 300V$, the transient rating is 2500V; and for $300V < \text{mains} \leq 600V$, the transient rating is 4000V).

3.1.6 Ratings

Table 3-1: RADWIN TV White Space Model Ratings

| Model Name | Input Voltage & Current | Enclosure Type | Oper. Temp |
|--------------------------------|-------------------------|----------------|--------------|
| TV White Space Base Station | 41.2-57VDC, 1.6A | IP67/Type 4 | -40C to +60C |
| TV White Space Subscriber Unit | 42.5-57VDC, 0.7A | IP67/Type 4 | -40C to +60C |

Appendix A: Wiring Specifications

A.1 Scope of this Appendix

This appendix shows wiring specifications for the HBS and SU.

A.1 Radio unit-PoE Cable (HBS and SU)

The radio unit-PoE cable is shielded/outdoor class CAT-5e, 4 twisted-pair 24 AWG terminated with RJ-45 connectors on both ends. A cable gland on the radio unit side provides hermetic sealing.

The following table shows the connector pinout:

Table A-1: Radio unit-PoE RJ-45 Connector Pinout

| Function | Color | PoE | ODU |
|-----------|--------------|-----|-----|
| Rx N | White/Green | 1 | 1 |
| Rx T | Green | 2 | 2 |
| Tx T | White/Orange | 3 | 3 |
| Tx N | Orange | 6 | 6 |
| Power (+) | Blue | 4 | 4 |
| Power (+) | White/Blue | 5 | 5 |
| Power (-) | White/Brown | 7 | 7 |
| Power (-) | Brown | 8 | 8 |

Table A-2: LAN-GbE PoE RJ-45 Connector Pinout

| Function | Color | PoE | LAN |
|-------------------|--------------|-----|-----|
| TxRx A | White/Green | 1 | 1 |
| TxRx A | Green | 2 | 2 |
| TxRx B | White/Orange | 3 | 3 |
| TxRx B | Orange | 6 | 6 |
| TxRx C & Power(+) | Blue | 4 | 4 |
| TxRx C & Power(+) | White/Blue | 5 | 5 |
| TxRx D & Power(-) | White/Brown | 7 | 7 |
| TxRx D & Power(-) | Brown | 8 | 8 |

A.2 User Port Connectors

A.2.1 LAN Port

The LAN 10/100BaseT interface terminates in an 8-pin RJ-45 connector, wired in accordance to [Table A-3](#).

Table A-3: Fast Ethernet Connector Pinout

| Function | Signal | Pin |
|--------------------------|--------|-----|
| Transmit Data (positive) | TD (+) | 1 |
| Transmit Data (negative) | TD (-) | 2 |
| Receive Data (positive) | RD (+) | 3 |
| Receive Data (negative) | RD (-) | 6 |

A.3 DC Power Terminals

A.3.1 DC PoE

DC power terminals are as follows:

Table A-4: Terminal Block 2-pin -48VDC

| Function | Pin |
|----------|-------|
| + | Right |
| - | Left |

Appendix B: About Antennas

B.1 Scope of this Appendix

This appendix provides some basic information and considerations regarding antennas and what you need to take into account when configuring antenna parameters.

B.1 Antenna Issues

The choice of Tx Power, antenna gain and cable loss (between the radio and the antenna) determines the EIRP and is affected by such considerations as radio limitations and regulatory restrictions.

Before proceeding to antenna installation details, the following background information should be considered:

B.2 About Single and Dual Antennas

Each RADWIN radio is actually made of two radio transceivers (radios). The radios make use of algorithms that utilize both Spatial Multiplexing (also called MIMO) and Diversity resulting in enhanced capacity, range and link availability. The number of antennas (i.e. radios) used is determined by user configuration and by automatic system decisions, explained below.

B.2.1 Dual Antennas at the HBS and an SU

When using dual antennas at both sites (single bipolar antenna or two mo-unipolar antennas) you can choose between Spatial Multiplexing Mode and Diversity Mode.

Spatial Multiplexing Mode

Under this mode, the system doubles the link capacity. At the same time, it keeps the same rate and modulation per radio as was used with single antenna, thus increasing capacity, range and availability.

For example with a dual antenna RADWIN TV White Space can transmit at modulation of 64QAM and FEC of 5/6 and get an air rate of 130 Mbps, compared to 65 Mbps with single antenna.

To work in this mode, each antenna port must be connected to an antenna, the RSS level in both receivers should be balanced and a minimal separation between the antennas must be maintained. (For example, by using dual polarization antennas a cross polarization separation is attained).

Upon selecting Antenna Type as Dual, RADWIN TV White Space automatically selects this mode and doubles the air rates.

The RADWIN Manager indicates a case of unbalanced RSS between the two antennas in the HBS panels.

Diversity Mode

(not applicable for FCC products)

Diversity Mode uses two antennas to improve the quality and reliability of the link. Often, there is not a clear line-of-sight (LOS) between transmitter and receiver. Instead the signal is reflected along multiple paths before finally being received.

Each such “bounce” can introduce phase shifts, time delays, attenuations, and even distortions that can destructively interfere with one another at the aperture of the receiving antenna. Antenna diversity is especially effective at mitigating these multi-path situations.

This is because multiple antennas afford a receiver several recordings of the same signal. Each antenna will be exposed to a different interference environment. Thus, if one antenna is undergoing a deep fade, it is likely that another has a sufficient signal. Collectively such a system can provide a robust link.

Antenna diversity requires antenna separation which is possible by using a dual-polarization antenna or by two spatially separated antennas.

Use Diversity instead of Spatial Multiplexing in the following situations:

- When the system cannot operate in Spatial Multiplexing Mode
- When one of the receivers has high interference compared to the second receiver (i.e. the system is “unbalanced”)
- When you achieve higher capacity in Diversity Mode than in Spatial Multiplexing Mode
- When high robustness is of importance and the capacity of Diversity Mode is sufficient (up to 25 Mbps full duplex)

B.2.2 Single Antennas at Both Sites

By selecting a single antenna at the HBS and SU, the ODUs operate with a single radio that is connected to the ANT 1 connector. The second radio is automatically shut down.

B.2.3 Single at One Site, Dual Antennas at the Other

In this mode one of the sites uses the ODU with a single antenna while the other site uses the ODU with a dual antenna.

The advantages in this mode in comparison to using a single antenna in both sites are doubled total Tx Power and additional polarization and/or space diversity (depending on the polarization of installed antennas).

The air rates used in this mode are same as when using single antennas in both sites.

Table B-1 summarizes the situation: (SM =Spatial Multiplexing)

Table B-1: Spatial Multiplexing - Diversity settings

| Number of Antennas | | Mode | | Max Full Duplex Capacity |
|--------------------|--------|----------------------|----------------------|--------------------------|
| Site A | Site B | Site A | Site B | |
| 2 | 2 | Spatial Multiplexing | Spatial Multiplexing | 50 Mbps |
| | | Diversity | Diversity | 25 Mbps |
| 2 | 1 | Diversity | Single | 25 Mbps |
| 1 | 2 | Single | Diversity | 25 Mbps |
| 1 | 1 | Single | Single | 25 Mbps |

Site A and B may be HBS or SU.

B.3 Considerations for Changing Antenna Parameters

Let:

max Available Tx Power denote the maximum Tx Power practically available from an ODU. (It appears as Tx Power per Radio.)

maxRegEIRP denote the maximum EIRP available by regulation. It will be determined by three factors:

- per band/regulation
- per channel bandwidth
- antenna gain

maxRegTxPower denote the maximum regulatory Tx Power for the equipment, also having regard the above three points.

Then, the following relationship must be satisfied:

$$\text{maxAvailableTxPower} \leq \min(\text{maxRegEIRP} - \text{AntennaGain} + \text{CableLoss}, \text{maxRegTxPower}) \quad \dots (*)$$

The Tx Power (per radio) indicates the power of each radio inside the ODU and is used for Link Budget Calculations. The Tx Power (System) shows the total transmission power of the ODU and is used to calculate the EIRP according to regulations.



- The Max EIRP level will be automatically set according to the selected band and regulation.

The inequality (*) above is always satisfied by the system in accordance with the relevant regulation.

The precise relationship between the items in inequality (*) is as follows: Required Tx Power (per radio) will be adjusted down to the lesser of the value entered and maxAvailableTxPower

- Tx Power (system) is maxAvailableTxPower + 3 (for 2 radios)
- Max EIRP is maxRegEIRP.
- EIRP is maxAvailableTx Power + Antenna Gain - Cable Loss

Appendix C: Terminology

Table C-1: Terminology (Sheet 1 of 4)

| Term | Description |
|--------------------|---|
| Assured throughput | Actual number of timeslots allocated to a radio unit. |
| ACS | Automatic Channel Selection. Option that instructs the radio to choose which frequency to use. Enabling or disabling this option has various ramifications as shown in the documentation. |
| ATPC | Automatic Transmit Power Control |
| BE | Best Effort: A level of priority for traffic in which users receive dynamic resource allocation according to overall demand. They are not guaranteed resources. See also CIR . |
| BFD | Bidirectional Forwarding Detection. A network protocol used to detect faults between two forwarding engines connected by a link. |
| BS | Base Station: a radio that can transmit and receive to more than one point. See also HBS |
| CIR | Committed Information Rate: A level of priority for traffic in which users receive a guaranteed percentage of resources in addition to dynamic resources if available. See also BE . |
| CPE | Customer Premises Equipment |
| DBA | Dynamic Bandwidth Allocation: a method that allocates bandwidth between the various users of that same bandwidth in the network. |
| DBS | Dynamic Bandwidth Selection: When activating a base station, or when changing its bandwidth, if you choose the maximum value available for the bandwidth, the link may dynamically switch between the maximum value and values as low as 20MHz to ensure the best throughput. |
| DHCP | Dynamic Host Configuration Protocol: a protocol that automatically assigns IP addresses and other network configuration parameters. |

Table C-1: Terminology (Sheet 2 of 4)

| Term | Description |
|-------------|---|
| Diversity | A technique by which the reliability of a radio link is increased using multiple transmitting and receiving antennas, transmitting the same signal on all antennas. |
| Downlink | Data traffic from an HBS to an HSU, or Data traffic from an RT-A to an RT-B |
| DUO | Dual Band base station |
| EIRP | Equivalent (or Effective) Isotropically Radiated Power: The power that an antenna must emit to produce the peak power density in the direction of maximum antenna gain. In our cases, this is usually: System Tx Power + Antenna Gain - Cable Loss. |
| FAA | Federal Aviation Administration. A U.S. federal office that manages aviation regulations throughout the United States. |
| Fixed (HSU) | A “fixed” HSU remains in one location, as contrasted with a nomadic or mobile HSU, which does not remain in one location. |
| GHSS | GPS Hub Site Synchronization |
| GRE | Generic Routing Encapsulation. A communication protocol used to establish a direct, point-to-point connection between network nodes. GRE lets two peers share data they wouldn’t be able to share over the public network itself. |
| GRE Tunnel | A virtual point-to-point connection between two networks, using the GRE protocol to carry this out. |
| HBS | High capacity Base Station. Same as a BS |
| HMU | High capacity Mobility (subscriber) Unit. Similar to an HSU, but can be mobile. |
| HSC | Hub Sync Client: When using Hub Site Synchronization, one unit is a master (generates the sync pulses), and the other units are clients. |
| HSM | Hub Sync Master: When using Hub Site Synchronization, one unit is a master (generates the sync pulses), and the other units are clients. |
| HSU | High capacity Subscriber Unit. Same as an SU |
| IGMP | Internet Group Management Protocol |
| ISU | Integrated Synchronization Unit: a network device that provides a synchronization signal to underground HBSs. |
| ITHO | Intra-train handover mechanism |
| LFF | Large Form-Factor |

Table C-1: Terminology (Sheet 3 of 4)

| Term | Description |
|---------------|--|
| MD5 | Message digest algorithm: an authentication type for SNMPv3 connections. |
| MIMO | Multiple In, Multiple Out. A technique by which the capacity of a radio link is increased using multiple transmitting and receiving antennas, transmitting a different signal on all antennas. |
| MIR | Maximum Information Rate |
| Mobile (HSU) | A “mobile” HSU can move from location to location and provide service while it moves or when it is stationary. |
| Nomadic (HSU) | A “nomadic” HSU move from location to location but can only provide service when it is stationary. |
| ODU | Outdoor Unit: a generic term for any radio, and can usually be exchanged for HBS or HSU. |
| On-board | Items or subject matter that relates to the environment on or inside the train itself. Also called “Train Side” |
| PPPoE | Point-to-Point Protocol over Ethernet |
| PtMP | Point to Multi-Point: link from an HBS to several HSUs |
| PtP | Point to Point |
| RADIUS | Remote Authentication Dial-In User Service |
| RSS | Radio Signal Strength |
| QoS | Quality of Service |
| SBM | Smart Bandwidth Management |
| Sector | A group of radios that consists of one HBS and several HSUs that communicate with the HBS. |
| SFF | Small Form-Factor |
| SHA1 | Secure hash algorithm: an authentication type for SNMPv3 connections. |
| SLA | Service Level Agreement - the basic agreement between the service provider and its customer regarding certain aspects of the service provided. For example, what should be the data rate, throughput, jitter of the line, who should pay what fees, the mean time between failure (MTBF) of the equipment, and so forth, |
| SSM | Synchronization Status Message: Provides traceability of synchronization signals, and is used in the Synchronous Ethernet standard of communication. |
| SU | Subscriber Unit: a radio that can transmit and receive to one point. See also HSU |

Table C-1: Terminology (Sheet 4 of 4)

| Term | Description |
|-----------------|---|
| Sync E or SyncE | Synchronous Ethernet: A standard of communication for ethernet that provides a synchronization signal to network elements that need such a signal. |
| TBS | Transportation Base Station. Similar to an HBS or BS, but used with high-speed transportation applications. |
| TDWR | Terminal Doppler Weather Radar: a type of radar station used in the U.S. and other countries for weather reporting. If a radio unit is installed close enough to one of these stations, the FCC requires that certain actions must be taken on the part of the customer. Regulations in other countries varies. |
| TMU | Transportation Mobile Unit. Similar to an SU |
| Track Side | Items or subject matter that relates to the environment not on or inside the train. It is not limited to precisely next to the track. Also called "wayside" |
| Train Side | Items or subject matter that relates to the environment on or inside the train itself. Also called "On-board" |
| TSN | Time Sensitive Network |
| Uplink | Data traffic from an HSU to an HBS, or Data traffic from an RT-B to an RT-A |
| VMU | Vehicular Mobile Unit |
| Wayside | Items or subject matter that relates to the environment not on or inside the train. It is not limited to precisely next to the track. Also called "Track Side" |
| WI | Web Interface: web-based application that provides simple configuration capabilities for the radio units. |
| WISPA | Wireless Internet Service Provider Association. An organization that manages registration of wireless devices that operate close to TDWR facilities run by the FAA. |
| VRRP | Virtual Router Redundancy Protocol - a networking protocol that provides for automatic assignment of available IP routers to participating hosts. |

Appendix D: Certified Antennas

D.1 For Deployment in U.S.

Radio devices that bear the following FCC/IC IDs refer to [Table D-1](#) below:

FCC ID: Q3K-500TVWSBS for HBS

FCC ID: Q3K-500TVWSSU for HSU

Only the antennas shown in the tables below or antennas of the same type with lower gain are approved for use in this system. The antennas must be installed so as to provide a minimum separation distance from bystanders as specified in the tables below:

Table D-1: Frequency Band 470-698 MHz

| Cat. No. | Type | Gain (dBi) | Dir BW | Tx Power per chain (dBm) | Min. Safe Distance (cm) |
|----------------|-------------------|-------------------|--------|--------------------------|-------------------------|
| Not applicable | Integrated for SU | 8.0 | 75° | 21 | 20 |
| RW-9061-0407 | Base Station | 12.5 ^a | 90° | 22 | 30 |

a. Including 0.3 dB feeder loss

D.1 For Deployment in EU Member States

Table D-2: Frequency Band 470-710 MHz

| Cat. No. | Type | Gain (dBi) | Dir BW | Tx Power per chain (dBm) | Min. Safe Distance (cm) |
|----------------|-------------------|-------------------|--------|--------------------------|-------------------------|
| Not applicable | Integrated for SU | 8.0 | 75° | 35 | 20 |
| RW-9061-0407 | Base Station | 12.5 ^a | 90° | 41 | 34 |

- a. Including 0.3 dB feeder loss

Regulatory Compliance

General Note

This system has achieved Type Approval in various countries around the world. This means that the system has been tested against various local technical regulations and found to comply. The frequency bands in which the system operates may be “unlicensed” and in these bands, the system can be used provided it does not cause interference.

For information on the restrictions on putting the device into service please contact your national telecommunication authorities.

FCC - Compliance

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

Consult the dealer or an experienced radio/TV technician for help.

Changes or modifications to this equipment not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

RF Exposure

For the safety of the general public it is recommended to keep a minimum safe distance from radiating antennas according to the table below:

Frequency Band 470-698 MHz

| Cat. No. | Type | Gain (dBi) | Dir BW | Tx Power per chain (dBm) | Min. Safe Distance (cm) |
|----------------|-------------------|-------------------|--------|--------------------------|-------------------------|
| Not applicable | Integrated for SU | 8.0 | 75° | 21 | 20 |
| RW-9061-0407 | Base Station | 12.5 ^a | 90° | 22 | 30 |

a. Including 0.3 dB feeder loss



Warning

It is the responsibility of the installer to ensure that when using the outdoor antenna kits in the United States (or where FCC rules apply), only those antennas certified with the product are used. The use of any antenna other than those certified with the product is expressly forbidden by FCC rules 47 CFR part 15.204.



Warning

It is the responsibility of the installer to ensure that when configuring the radio in the United States (or where FCC rules apply), the Tx power is set according to the values for which the product is certified. The use of Tx power values other than those, for which the product is certified, is expressly forbidden by FCC rules 47 CFR part 15.204.

Indoor Units comply with part 15 of the FCC rules. Operation is subject to the following two conditions:

- (1) These devices may not cause harmful interference.
- (2) These devices must accept any interference received, including interference that may cause undesired operation.



Caution

Outdoor units and antennas should be installed ONLY by experienced installation professionals who are familiar with local building and safety codes and, wherever applicable, are licensed by the appropriate government regulatory authorities. Failure to do so may void the product warranty and may expose the end user or the service provider to legal and financial liabilities. Resellers or distributors of this equipment are not liable for injury, damage or violation of regulations associated with the installation of outdoor units or antennas. The installer should configure the output power level of antennas according to country regulations and antenna type.



- Where Outdoor units are configurable by software to Tx power values other than those for which the product is certified, it is the responsibility of the Professional Installer to restrict the Tx power to the certified limits.
- This product was tested with special accessories - indoor unit (IDU or PoE), FTP CAT-5e shielded cable with sealing gasket, 10 AWG grounding cable - which must be used with the unit to insure compliance.



The system must be professionally installed to ensure compliance with the Part 15 certification. It is the responsibility of the operator and professional installer to ensure that only certified systems are deployed in the United States. The use of the system in any other combination (such as co-located antennas transmitting the same information) is expressly forbidden. The radio must be installed and used in strict accordance with the manufacturer's instructions as described in this guide. Any other installation or use of the product violates FCC Part 15 regulations.



It is the responsibility of the installer to ensure that when using the outdoor antenna kits in the United States (or where FCC rules apply), only those antennas certified with the product are used. The use of any antenna other than those certified with the product is expressly forbidden by FCC rules 47 CFR part 15.204. A list of approved external antennas can be found in the Certified Antennas appendix .



It is the responsibility of the operator and professional installer to ensure that when configuring the radio in the United States (or where FCC rules apply), the Tx power is set according to the values for which the product is certified. The use of Tx power values other than those, for which the product is certified, is expressly forbidden by FCC rules 47 CFR part 15.204



Under regulatory environments supporting other than FCC rules: Where Outdoor units are configurable by software to Tx power values other than those for which the product is certified, it is the responsibility of the Professional Installer to restrict the Tx power to the certified limits.

This product was tested with special accessories indoor unit (IDU or PoE), FTP CAT-5e shielded cable with sealing gasket, 10 AWG grounding cable - which must be used with the unit to insure compliance.



Radio devices using external antennas operating in the TVWS band must comply with the EIRP limits as specified in the Certified Antennas appendix

EU – Compliance



Radio transmitters operating in the EU need to comply the RE-DIRECTIVE 2014/53/EU, EMC Directive 2014/30/EU, Low Voltage Directive 2014/35/EU.

The RADWIN TV White Space product complies with the requirements of the harmonized standard ETSI EN 301 598 V2.1.1

For Norway and Sweden only

Equipment connected to the protective earthing of the building installation through the mains connection or through other equipment with a connection to protective earthing - and to a cable distribution system using coaxial cable, may in some circumstances create a fire hazard. Connection to a cable distribution system has therefore to be provided through a device providing electrical isolation below a certain frequency range (galvanic isolator, see EN 60728-11).

Norway

Utstyr som er koplet til beskyttelsesjord via nettplugg og/eller via annet jordtilkoplest utstyr - og er tilkoplest et kabel-TV nett, kan forårsake brannfare. For å unngå dette skal det ved tilkopling av utstyret til kabel-TV nettet installeres en galvanisk isolator mellom utstyret og kabel-TV nettet

Sweden

Utrustning som är kopplad till skyddsjord via jordat vägguttag och/eller via annan utrustning och samtidigt är kopplad till kabel-TV nät kan i vissa fall medföra risk för brand. För att undvika detta skall vid anslutning av utrustningen till kabel-TV nät galvanisk isolator finnas mellan utrustningen och kabel-TV nätet.

Unregulated

In countries where the radio is not regulated the equipment can be operated in any regulation configuration, best results will be obtained using Universal regulation configuration.

Safety Practices

Applicable requirements of National Electrical Code (NEC), NFPA 70; and the National Electrical Safety Code, ANSI/IEEE C2, must be considered during installation.

NOTES:

1. A Primary Protector is not required to protect the exposed wiring as long as the exposed wiring length is limited to less than or equal to 140 feet, and instructions are provided to avoid exposure of wiring to accidental contact with lightning and power conductors in accordance with NEC Sections 725-54 (c) and 800-30.

In all other cases, an appropriate Listed Primary Protector must be provided. Refer to Articles 800 and 810 of the NEC for details.

2. For protection of ODU against direct lightning strikes, appropriate requirements of NFPA 780 should be considered in addition to NEC.

3. For Canada, appropriate requirements of the CEC 22.1 including Section 60 and additional requirements of CAN/CSA-B72 must be considered as applicable.

4. Only UL Listed parts and components will be used for installation. Use UL Listed devices having an environmental rating equal to or better than the enclosure rating to close all unfilled openings.

5. Use min. 10AWG external protective earthing conductor.

RADWIN TV White Space

User Handbook

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